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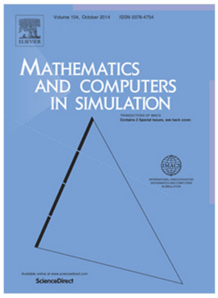

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A Parallel Implementation of a Cloud Dynamics Model with Cellular Automaton

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Abstract

The construction of computational models to simulate real systems enables their dynamics to be understood and analyzed, and the future evolution of these systems to be predicted. The benefits of using computational simulations are that they are more secure, save cost and time, since systems that do not already exist can be created without incurring the costs of building them, securely, and in less time than real ones. However, the simulation of complex systems needs a lot of calculations, usually run in high performance platforms which rely extensively on parallel computing. Atmospheric models are examples of complex systems, since they consist of a large number of variables, many differential equations, and space-temporal evolution. A cellular automaton (CA) is a numerical method used in simulations of systems represented by a matrix of cells where the state transitions depend on the state of neighboring cells. This work sets out a proposal for the parallel implementation of a two dimensional CA, using an atmospheric model of cloud dynamics as a case study. The tests were performed in a shared memory architecture with a 12-core processor and a 192-core GPU. Several experiments were performed in order to assess stability, precision, and performance in an isolated atmospheric area. The experiments evaluated the performance of the parallel model relative to the sequential one, using runtime and speedup as metrics. The results showed that the parallel model is stable from the point of view of thermal equilibrium. Moreover, the performance tests showed that the runtime decreases as the number of threads increases until the limit of the number of computing cores, reaching a performance gain of up to 6.5 times better than the sequential version.

Keywords: Cellular Automata, Complex Systems, Cloud Dynamics, Simulation, Parallel Programming

1. Introduction

Simulations are studies of real systems using models that can describe and understand the behaviors of such systems and/or to evaluate strategies for operating them [1]. These models can be installed and run in supercomputers when the problem is complex, i.e., many items of data and calculations are processed. In recent years, computational simulations have been introduced in several sectors in society, companies, and in scientific and academic fields. Computational simulations can provide economic, time-saving, and security benefits. Simulations can be performed to solve problems in several areas such as Physics [2], Medicine [3], Biology [4], Chemistry [5], Engineering [6], Economics [7], Sociology [8], and Climatology [9].

In order to simulate a real system, a simulation method needs to be chosen [10, 11, 12, 13, 14]. Cellular automata (CAs) [12] are discrete models on which many areas, such as Computation, Mathematic, Physics, Complexity Science, and Biology, are conducting research. CAs consist of a grid of cells, each with a finite number of states. Each cell is